CHAPTER 3

POWER GENERATION

Generators play an important part in your assignment with the Seabees. Whether operating a generator as a main power source or as standby power or as emergency power, you need a through knowledge of their hookup, operation, and maintenance.

At the completion of this chapter, you should know how to install generators of the advanced-base type, stand a generator watch, perform preventive maintenance, and make minor repairs on power generators and control equipment.

Theory for both dc and ac generators is included in Navy Electricity and Electronics Training Series (NEETS), Module 5. Generator theory will not be covered in this chapter. Keep in mind that the generator (alternator) in an automobile works on the same principle as does the huge turbine generator used in a nuclear power station.

INSTALLATION AND SERVICING GENERATORS

Most of the generators you are likely to work with in the Naval Construction Force (NCF) range in size from 5 kW to 200 kW. Generators in these sizes range in weight from 488 pounds (221.4 kg) to 10,500 pounds (4770 kg). All of these units are mounted on skid bases. Lifting and tie-own attachments are provided. All have provisions for lifting with a forklift of the appropriate capacity (with the exception of the 5-kW gas-driven generator set, which does not include the forklift provision).

Several factors should be considered before a final decision is made about where to locate a generator. The noise levels of generators sized from 5 kW to 200 kW range from 77 dBa to 93 dBa (adjusted decibels) at 25 feet. Generator noise is a problem in low-noise level or quiet areas (libraries, offices, hospitals, chapels, etc.). The operating 60-kW generator, for example, presents a noise hazard (84 dBa to 91 dBa, depending on the model) to all personnel in the immediate area. The noise level near the unit exceeds the allowable limits for unprotected personnel. Therefore, everyone working around the generator needs single (noise < 84 dBa) or double hearing protection (noise > 104 dBa).

Placing a generator set near points of large demand will reduce the size of wire required, hold the line losses to a minimum, and afford adequate voltage control at the remote ends of the lines.

The following points should be considered before an exact site is chosen for a generator set:

1. Generators must not be closer than 25 feet (7.6 meters) to a load because of noise, fire hazard, and air circulation.

2. The set must be placed on a stable, preferably level, foundation. It should not be operated while inclined more than 15 degrees from level.

3. The site must be within 25 feet (7.6 meters) of any paralleled generator set and within 25 feet (7.6 meters) of any auxiliary fuel supply.

4. When preparing a temporary installation, you should move the generator set as close to the jobsite as practical. In an area where the ground is soft, do not remove the wood-skid base if you have not already done so. The wood-skid base will establish a firm foundation on soft ground, mud, or snow; otherwise, use planks, logs, or other material for a base in an area where the ground is soft.

Although advanced-base portable generators are designed to be operated outdoors, prolonged exposure to wind, rain, and other adverse conditions will definitely shorten their lives. When the generators are to remain on the site for any extended period of time, they should be mounted on solid-concrete foundations and should be installed under some type of shelter.

There are no predrawn plans for shelters for a small advanced-base generating station. The shelter will be an on-the-spot affair—the construction of which is determined by the equipment and material on hand plus your ingenuity, common sense, and ability to cooperate with personnel in other ratings. Before a Builder can get started on the shelter, you will have to furnish information, such as the number of generators to be sheltered, the dimensions of the generators, the method of running the generator load cables from the generator to the panelboard and from the panelboard to the feeder

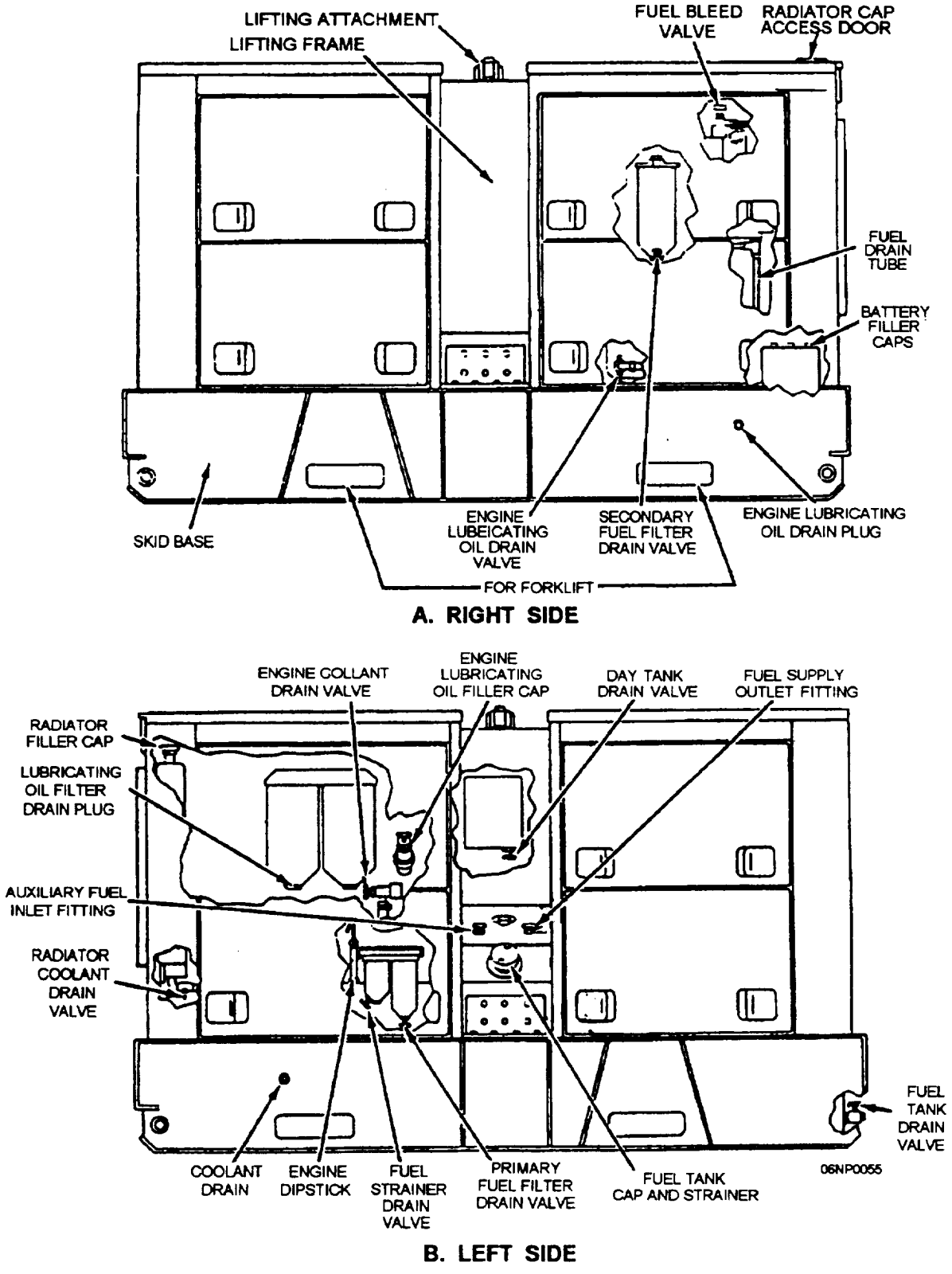

Figure 3-1.—Typical 60-kW generator set.

system outside the building, and the arrangement of the exhaust system.

Large generator units may have, connected or attached to them, engine equipment that requires extra space and working area. Included in this equipment are air-intake filters, silencers for air intake and exhaust, fuel and lubricating oil pumps, tanks, filters, and strainers. Also included are starting gear, isochronous regulating governors with over-speed trips, safety alarm and shutdown devices, gauges and thermometers, turning gear, along with platforms, stairs, and railings.

An even larger and more complete power plant may require separate equipment, such as a motor-driven starting air compressor and air storage tanks; motor-driven pumps for jacket water and lubricating oil cooling, or heat exchangers with raw cooling water pumps and lubricating oil coolers; and tanks that include day-fuel storage.

Be sure to provide enough working space around each unit for repairs or disassembly and for easy access to the generator control panels.

Installation specifications are available in the manufacturer's instruction manual that accompanies each unit. Be sure to use them. Consulting with the Builder about these specifications may help cut installation costs and solve future problems affecting the shelter of the generator.

SERVICING THE GENERATOR

Before the set is operated, it must be serviced. We will use the 60-kW generator set as an example for discussing the servicing of the set after you receive it. As you read this discussion, refer to figure 3-1 for locating fill and drain points and drain valves.

Batteries

All 5-kW through 750-kW generator sets are furnished with dry-charged batteries less the electrolyte. Battery electrolyte must be requisitioned separately.

You must be cautious when installing, activating, or maintaining batteries. Before we discuss connecting and servicing batteries, let's look at a few safety points you must know about.

WARNING

Do not smoke or use an open flame in the vicinity of batteries when servicing them. Batteries generate hydrogen a highly explosive gas. When removing batteries, always remove both negative cables before removing the positive cables (fig. 3-2).

Battery electrolyte contains sulfuric acid and can cause severe burns. It is highly toxic to the skin, eyes, and respiratory tract. Skin, eyes, and face (chemical splash goggles, face shields) and respiratory protection are required. Whenever electrolyte comes into contact with the body, the eyes, or the clothing, you must rinse immediately with clean water, remove contaminated clothing, and then go to sickbay or the medical clinic for a thorough examination.

The 60-kW generator set is equipped with two 12-volt, 100-ampere-hour batteries. The batteries are located under the radiator (fig. 3-1, view A) on aroll-out tray (fig. 3-3). They are connected in series to supply 24 volts dc for starting the generator set and operating direct current components. Two slave receptacles (fig. 3-2), connected in parallel, permit easy connection to the batteries to supply or obtain battery power. As we

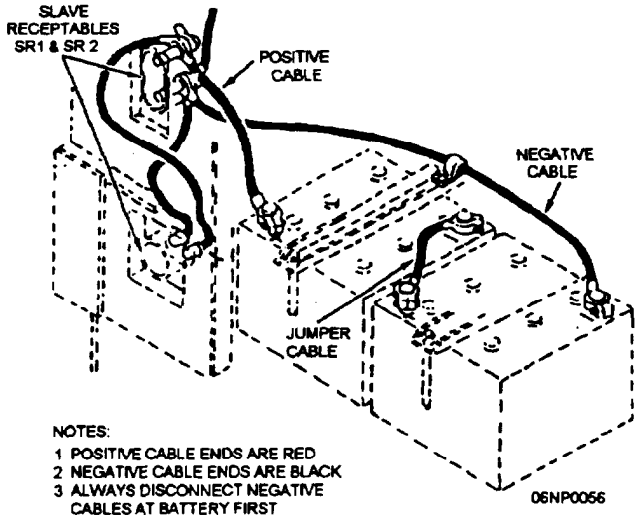

Figure 3-2.—Battery cable connections and slave receptacles.

discuss activating the batteries, refer to steps 1 through 3 (following) and figure 3-3.

1. Open the battery compartment door and secure it to the radiator grille with the door holder.

2. Depress the button on top of the quick-release pins, lift up the pins, and pull the roll-out tray assembly out.

3. Remove the filler caps. When you have electrolyte of the correct specific gravity, do not dilute it, but fill the battery cells to the cell slots.

When you prepare your own electrolyte, consult a mixing chart (table 3-1). In this case, use the specific gravity value recommended in the instruction manual.

Table 3-1.—Electrolyte Mixing Chart

SPECIFIC GRAVITY DESIRED	USING 1.835 SPECIFIC GRAVITY ACID		USING 1.400 SPECIFIC GRAVITY ACID	
	PARTS OF WATER	PARTS OF ACID	PARTS OF WATER	PARTS OF ACID
1.400	3	22	..	..
1.345	2	1	1	7
1.300	5	2	2	5
1.290	8	3	9	20
1.275	11	4	11	20
1.250	13	4	3	4
1.225	11	3	1	1
1.200	13	3	13	10

The temperature of the electrolyte when placed in the cells should be between 60°F and 90°F. IT SHOULD NEVER EXCEED 90°F.

WARNING

Be sure to add the acid to the water s-l-o-w-l-y, stirring constantly and thoroughly.

A chemical reaction occurs when you add electrolyte to the battery, thereby causing the battery to heat. Cool it artificially (cooling fans) or allow it to stand at least 1 hour before placing it in service.

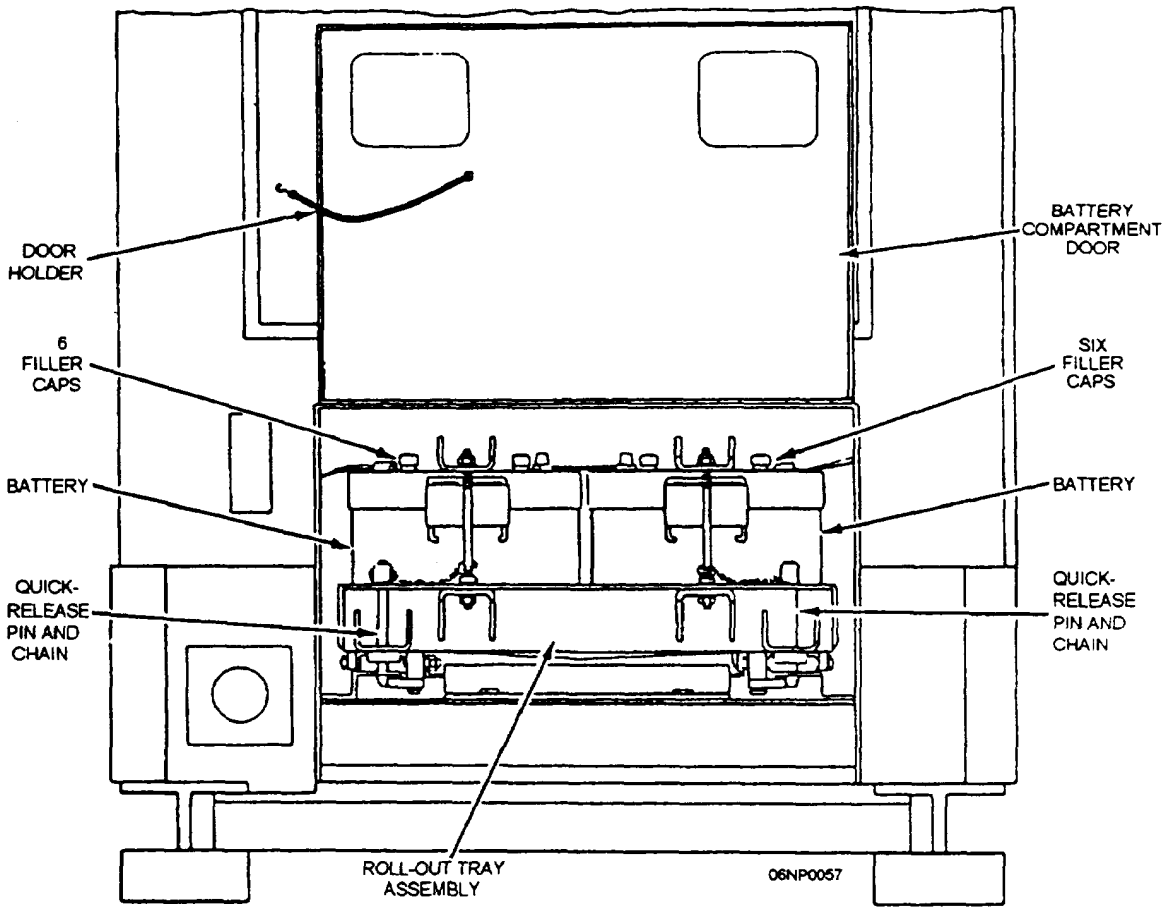

Figure 3-3.—Battery compartment.

You will notice at the end of the cooling period that the level of the electrolyte has dropped because of the electrolyte soaking into the plates and separators. Before placing the battery in service, restore the electrolyte to its proper level. Remove any electrolyte spilled on the battery, using a cloth dampened with a solution of bicarbonate of soda and water.

Although you can place the battery in service 1 hour after filling it with electrolyte, do so only in an emergency. If at all possible, give the battery an initial light charge.

After the battery has been charged, connect the battery into the starting system of the prime mover, as shown in figure 3-2. Always connect the negative cable last.

4. Push in the roll-out tray assembly and install the quick-release pins (fig. 3-3).

Battery Charging

The manufacturer's manual may specify charging procedures for the type of battery you are to charge. If so, follow those procedures.

There are several types of battery charges, but you will generally use a normal charge, an equalizing charge, or a fast charge. We will discuss these three types of charges briefly. For more information on storage or dry-cell batteries and battery charging, refer to the Navy Electricity and Electronics Training Series (NEETS), NAVEDTRA 172-01-00-88 (Module 1).

NORMAL CHARGE.—A normal charge is a routine charge that is given according to the battery nameplate data during the ordinary cycle of operation to restore the battery to its charged condition,

EQUALIZING CHARGE.—An equalizing charge is a special extended normal charge that is given periodically to batteries as part of a maintenance routine. It ensures that all the sulfate is driven from the plates and that all the cells are restored to a condition of maximum specific gravity. The equalizing charge is continued until the specific gravity of all cells, corrected for temperature, shows no change for a 4-hour period.

FAST CHARGE.—A fast charge is used when a battery must be recharged in the shortest possible time. The charge starts at a much higher rate than is normally used for charging. It should be used only in an emergency, as this type of charge may be harmful to the battery.

CHARGING RATE.—Normally, the charging rate of Navy storage batteries is given on the battery nameplate. If the available charging equipment does not have the desired charging rates, the nearest available rates should be used; however, the rate should never be so high that violent gassing occurs.

CHARGING TIME.—The charge must be continued until the battery is fully charged. Frequent readings of specific gravity should be taken during the charge and compared with the reading taken before the battery was placed on charge.

GASSING.—When a battery is being charged, a portion of the energy breaks down the water in the electrolyte. Hydrogen is released at the negative plates and oxygen at the positive plates. These gases bubble up through the electrolyte and collect in the air space at the top of the cell. If violent gassing occurs when the battery is first placed on charge, the charging rate is too high. If the rate is not too high, steady gassing develops as the charging proceeds, indicating that the battery is nearing a fully charged condition.

WARNING

A mixture of hydrogen and air can be dangerously explosive. No smoking, electric sparks, or open flames should be permitted near charging batteries.

CHARGING PROCEDURE.—If the instruction manual for the generator set is not available or if it does not give the battery a charging procedure, proceed as follows: Connect the positive battery charger terminal to the positive battery terminal and the negative charger terminal to the negative battery terminal.

Charge the battery at a low rate (about 5 amperes) until the voltage and specific gravity, corrected to 80°F (27°C) remains constant for at least 4 hours. If the temperature of the electrolyte reaches 110°F (43°C), reduce the charging rate or stop the charge until the battery cools. NEVER PERMIT THE TEMPERATURE TO EXCEED 115°F (46°C). During the charging, replenish any water lost by evaporation.

Hydrometer

A hydrometer is the instrument used to measure the amount of active ingredients in the electrolyte of the battery. The hydrometer measures the SPECIFIC GRAVITY of the electrolyte. Specific gravity is the ratio of the weight of the electrolyte to the weight of the same volume of pure water, The active ingredient, such as sulfuric acid or potassium hydroxide, is heavier than water. Because the active ingredient is heavier than water, the more active the ingredient in the electrolyte, the heavier the electrolyte will be; the heavier the electrolyte, the higher the specific gravity.

A hydrometer is a glass syringe with a float inside it. The float is in a hollow, glass tube, weighted at one end and sealed at both ends, with a scale calibrated in specific gravity marked on the side. The electrolyte to be tested is drawn into the hydrometer by the suction bulb. Enough electrolyte should be drawn into the hydrometer so that the float will rise. Hydrometers should not be filled to the extent that the float rises into the suction bulb. Since the weight of the float is at its base, the float will rise to a point determined by the weight of the electrolyte. If the electrolyte contains a large concentration of the active ingredient, the float will rise higher than if the electrolyte has a small concentration of the active ingredient.

To read the hydrometer, hold it in a vertical position and take the reading at the level of the electrolyte. Refer to the manufacturer's technical manual for battery specifications to find the correct specific gravity ranges. An example of what your manual may say about the specific gravity is that for a fully charged battery the specific gravity should be 1.280 ± 0.005. The manual may tell you to recharge the battery if the specific gravity is less than 1.250.

Always return the electrolyte in the hydrometer to the cell of the battery from which it was taken.

NOTE: Hydrometers should be flushed with fresh water after each use to prevent inaccurate readings. Storage battery hydrometers must not be used for any other purpose.

Perhaps it should be said that adding the active ingredient (sulfuric acid, for example) to the electrolyte of a discharged battery does not recharge the battery. Adding the active ingredient only increases the specific gravity of the electrolyte and does not convert the plates back to active material, and so does not bring the battery back to a charged condition. A charging current must be passed through the battery to recharge it.

Oil

You must check the engine crankcase oil level before operating the generator set. The engine dipstick (fig. 3-1, view B) is the crankcase oil level gauge. The dipstick in the generator engine is the shielded type, which allows checking the oil level while the engine is either stopped or running. The dipstick is stamped on both sides to indicate the two different oil levels. The engine running side is stamped as follows: "ADD," "FULL," and "RUNNING." The engine stopped side is stamped as follows: "ADD," "FULL," and "STOPPED." Be sure to use the appropriate add and full marks, depending on whether the engine is stopped or running. Also, ensure that the appropriate side of the dipstick is up when inserting it since the underside will be wiped in the gauge tube when the dipstick is removed, therefore, indicating a false oil level reading.

To check the oil level, first remove and wipe the oil from the dipstick. Loosen and remove the oil filler cap (fig. 3-1) to allow the pressure to escape. Reinsert the dipstick (with the appropriate side up) and remove it to observe the oil level. Add oil through the fill tube, as required, to obtain the "full" level on the dipstick. Be sure to use the proper grade of oil. A lubricant chart in the instruction manual furnished with each generator will show the proper grade of oil to use at the operating temperature.

Water

Check that the level of coolant is within 2 inches (51 mm) of the top of the radiator.

WARNING

Do not attempt to remove the radiator cap until the radiator has cooled to a point where there will be no built-up steam pressure. Failure to observe this warning could result in second- or third-degree bums.

Using an antifreeze solution tester, check that the antifreeze content is sufficient for the existing ambient temperature. Add antifreeze as required.

Whenever you fill the radiator with coolant after it has been drained, fasten a tag near the radiator cap. The tag should indicate the type of coolant and the degree of protection the coolant gives.

Regardless of the air temperature, be sure to use an antifreeze solution in the proportions recommended in the instruction manual for the generator.

Fuel

The fuel tank should be filled with clean fuel oil, strained if necessary. Service the fuel tank as follows:

WARNING

Always maintain constant metal-to-metal contact between the fuel tank filler neck and the spout of the fuel supply. That will prevent the possibility of sparking caused by static electricity.

Remove the fuel tank filler cap (fig. 3-1, view B), and fill the fuel tank with the proper fuel. (Refer to the instruction manual.) Replace the filler cap and wipe up any spilled fuel.

Remove the cap from the fuel tank drain valve and open the valve. Let water and sediment drain into an approved nonflammable container. When clean fuel runs out of the tank, close the drain valve and install the cap on the valve.

A day tank is one of the major components of the fuel system. It has a capacity to permit engine operation for a minimum of 5 minutes. The day tank also provides a settling point for contaminants (to prevent their entry into the engine) and supplies fuel to the engine fuel pump.

The day tank contains a dual type of float switch. The upper float operates in conjunction with the fuel solenoid valve to maintain a predetermined fuel level in the tank. The lower float initiates an engine shut-down sequence. This sequence is initiated in the event that the fuel level in the tank will permit operation of the generator set at the rated load for only 1 minute.

You must drain sediment and water from the day tank as you did from the fuel tank. Remove the cap from the day tank drain valve and open the valve. (Refer to fig. 3-1, view B, for the location of the tank and its drain valve.) Drain water and sediment into a container. Close the valve when clean fuel runs out of the tank, and install the cap back on the valve.

VENTILATION

WARNING

Do not operate the generator set in an enclosed area unless the exhaust gases are piped to the outside. Inhalation ofexhaust gases will result in serious injury or death.

Keep the area around an operating generator set well ventilated at all times so that the generator set will receive a maximum supply of air.

Consider ventilation when you install the units inside a building. Every internal combustionengine is a HEAT engine. Although heat does the work, excess amounts of it must be removed if the engine is to function properly. This can be accomplished by setting the radiator grille of the engine near an opening in the wall and providing another opening directly opposite the unit. In this manner, cool air can be drawn in and the hot air directed in a straight line outdoors. These openings can be shielded with adjustable louvers to prevent the entrance of rain or snow. In addition, when the generator is operating in extremely cold weather, the temperature in the room can be controlled by simply closing a portion of the discharge opening. Additional doors or windows should be provided in the shelter if the plants are installed in localities where the summer temperatures exceed 80°F at any time.

EXHAUST SYSTEM

The muffler and the exhaust pipe are connected to the turbocharger exhaust elbow (fig. 34) and provide a path for engine exhaust gases to exit the generator set. The muffler reduces the noise level of the engine exhaust. The discharge opening of the muffler is covered by a hinged cap to prevent water from entering the exhaust system when the generator is not operating.

Let's look at an example of an indoor installation. After bolting the generator set to the concrete pad and enclosing it in a shelter, you are about to vent the exhaust system to the outside. You lift the exhaust cap (fig. 3-4) and connect the gastight exhaust pipe to the discharge opening. You then extend the pipe through the wall (or roof) of the building in a route that includes no obstructions and a minimum number of bends. If you have arranged the pipe to slope away from the engine, condensation will not drain back into the cylinders. If the exhaust pipe has to be installed so that loops or traps are necessary, place a drain cock at the lowest point of the system. All joints must be perfectly tight; and where the exhaust pipe passes through the wall, you must take care to prevent the discharged gas from returning along the outside of the pipe back into the building. Exhaust piping inside the building must be covered with insulation capable of withstanding a temperature of 1500°F.

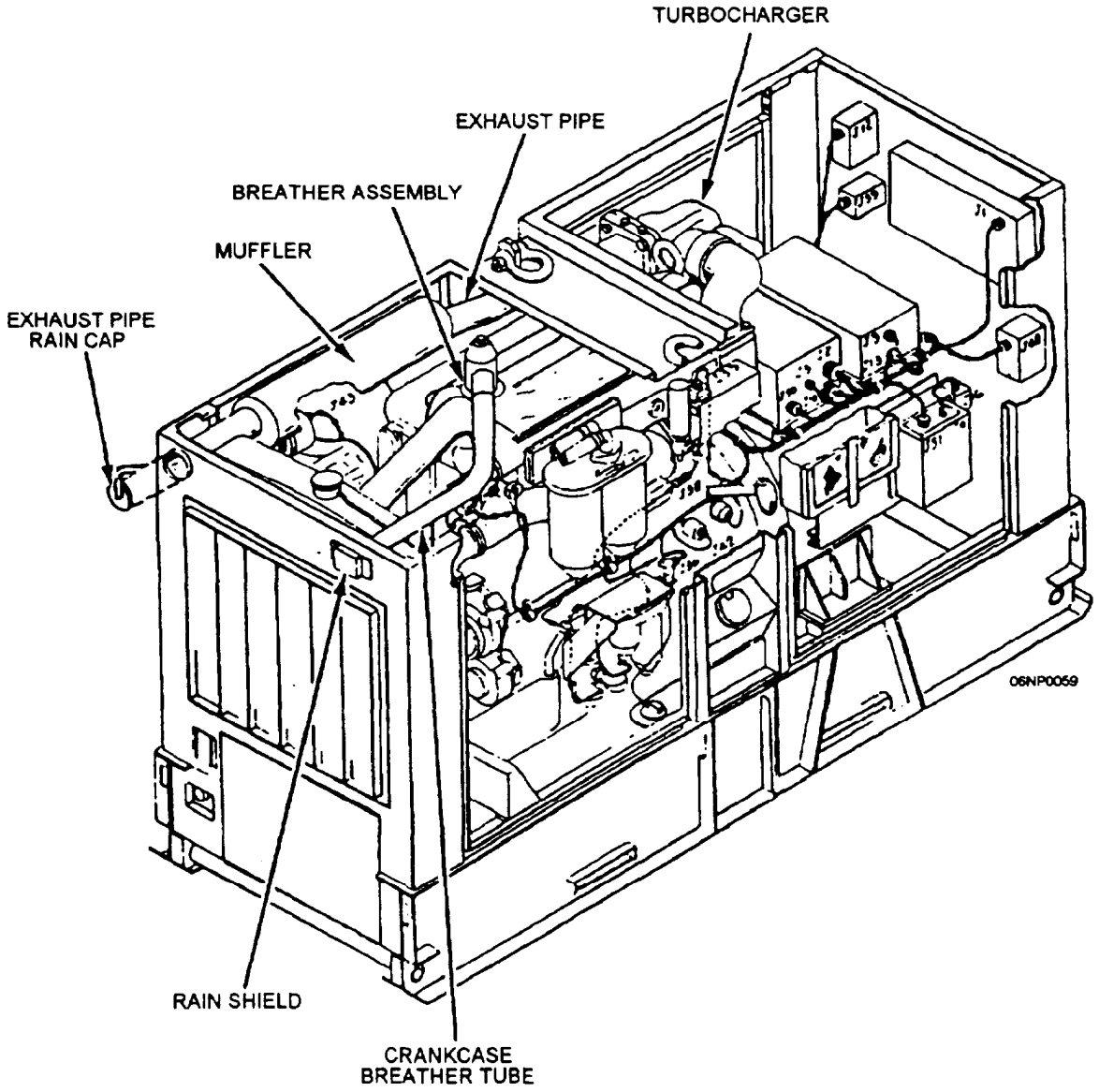

Figure 3-4.—Exhaust and breather system.

The crankcase breather tube (fig. 3-4) is clamped to the engine breather assembly. The breather tube provides a path for engine crankcase vapors to exit the generator set. A rain shield is provided at the tube outlet to prevent rain from entering the tube when the generator is used outdoors.

GROUNDING

The generator set must be connected to a suitable ground before operation.

WARNING

Electrical faults in the generator set, load lines, or load equipment can cause injury or electrocution from contact with an ungrounded generator.

The ground can be, in order of preference, an underground metallic water piping system (fig. 3-5, view A), a driven metal rod (fig. 3-5, view B), or a buried metal plate (fig. 3-5, view C). A ground rod must have a minimum diameter of 5/8 inch (41 mm) if solid or 3/4 inch (44 mm) if pipe. The rod must be driven to a minimum depth of 8 feet (2.44 M). A ground plate must have a minimum area of 2 square feet (0.186 square meter) and, where practical, be embedded below the permanent moisture level.

The ground lead must be at least No. 6 AWG (American Wire Gauge) copper wire. The lead must be bolted or clamped to the rod, plate, or piping system. Connect the other end of the ground lead to the generator set ground terminal stud (fig. 3-6, view A).

Use the following procedure to install ground rods:

1. Install the ground cable into the slot in the ground stud and tighten the nut against the cable.

2. Connect a ground rod coupling to the rod and install the driving stud in the coupling (fig. 3-6, view B). Make sure that the driving stud is bottomed on the ground rod.

3. Drive the ground rod into the ground until the coupling is just above the ground surface.

4. Connect additional rod sections, as required, by removing the driving stud from the coupling and installing another rod section in the coupling. Make sure the new ground rod section is bottomed on the ground rod section previously installed. Connect another coupling on the new section and again install the driving stud.

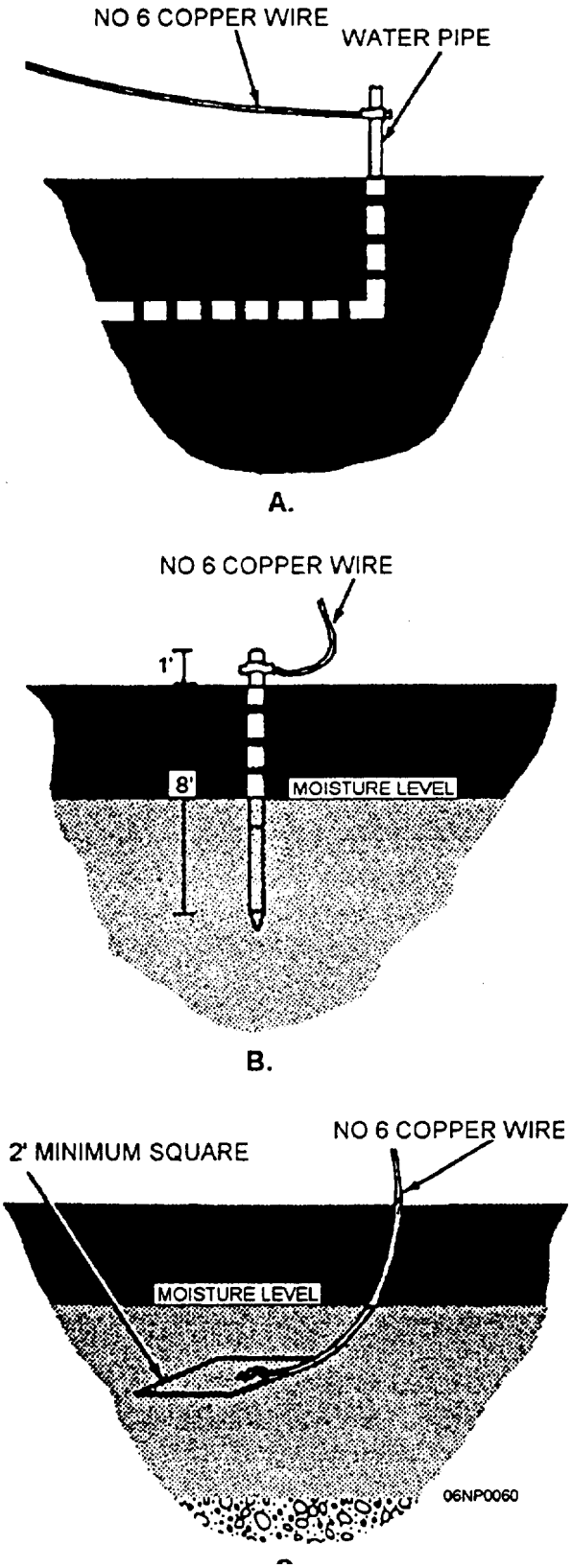

Figure 3-5.—Methods of grounding generators.

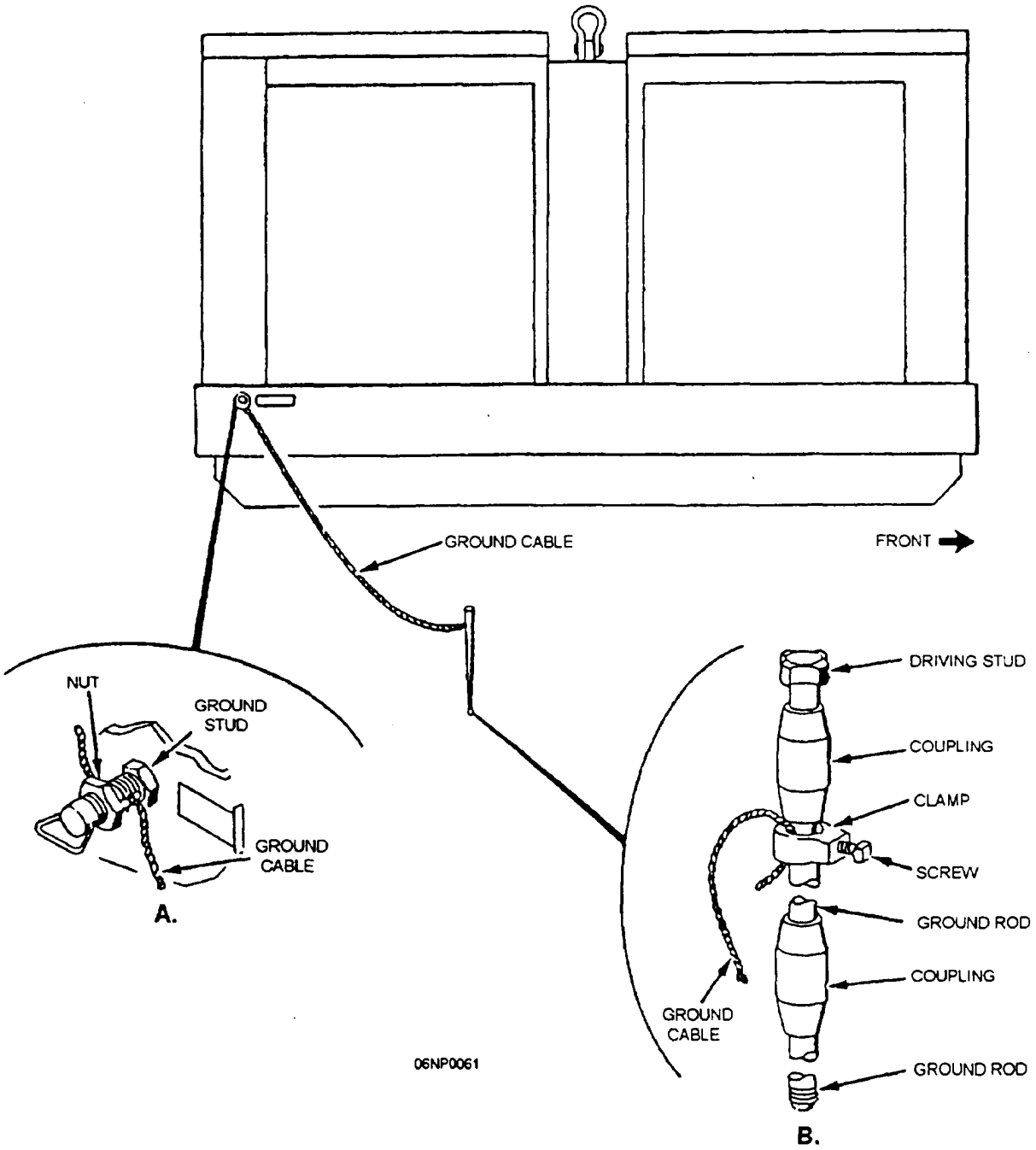

Figure 3-6.—Grounding procedure.

5. After the rod(s) have been driven into the ground, remove the driving stud and the top coupling.

NOTE: The National Electrical Code© states that a single electrode consisting of a rod, pipe, or plate that does not have a resistance to ground of 25 ohms or less will be augmented by additional electrodes. Where multiple rod, pipe, or plate electrodes are installed to meet the requirements, they will be not less than 6 feet apart.

The resistance of a ground electrode is determined primarily by the earth surrounding the electrode. The diameter of the rod has only a negligible effect on the resistance of a ground. The resistance of the soil is dependent upon the moisture content. Electrodes should be long enough to penetrate a relatively

permanent moisture level and should extend well below the frost line. Periodic earth resistance measurements should be made, preferably at times when the soil would be expected to have the least moisture.

You need to test the ground rod installation to be sure it meets the requirement for minimum earth resistance. The earth resistance tester may be used to perform the test. You should make this test before you connect the ground cable to the ground rod.

When ground resistances are too high, they may be reduced by one of the following methods:

1. Using additional ground rods is one of the best means of reducing the resistance to ground; for example, the combined resistance of two rods properly spaced and connected in parallel should be 60 percent of the resistance of one rod; the combined resistance of three rods should be 40 percent of that of a single rod.

2. Longer rods are particularly effective where low-resistance soils are too far below the surface to be reached with the ordinary length rods. The amount of improvement from the additional length on the rods depends on the depth of the low-resistance soils. Usually, a rather sharp decrease in the resistance measurements is noticeable when the rod has been driven to a low-resistance level.

3. Treating the soil around ground rods is a reliable and effective method for reducing ground resistance and is particularly suitable for improving high-resistance ground. The treatment method is advantageous where long rods are impractical because of rock strata or other obstructions to deep driving. There are two practical ways of accomplishing this result, as shown in figure 3-7. Where space is limited, a length of tile pipe is sunk in the ground a few inches from the ground rod (fig. 3-7, view A) and tilled to within 1 foot or so of the ground level with the treatment chemical. The best treatment chemicals for all situations cannot be covered within the scope of this manual. You may work with your engineering office to determine the possible corrosive effect on the electrode. Examples of suitable noncorrosive materials are magnesium sulfate, copper sulfate, and ordinary rock salt. The least corrosive is magnesium sulfate, but rock salt is cheaper and does the job.

The second method is applicable where a circular or semicircular trench can be dug around the ground rod to hold the chemical (fig. 3-7, view B). The chemical must be kept several inches away from coming into direct contact with the ground rod to avoid corrosion of the rod. if you wish to start the chemical action promptly, you should go ahead and flood the treatment material. The first treatment usually contains 50 to 100 pounds of material. The chemical will retain its effectiveness for 2 to 3 years. Each replenishment of the chemical extends the effectiveness for a longer period so that the necessity for future retreating becomes less and less frequent.

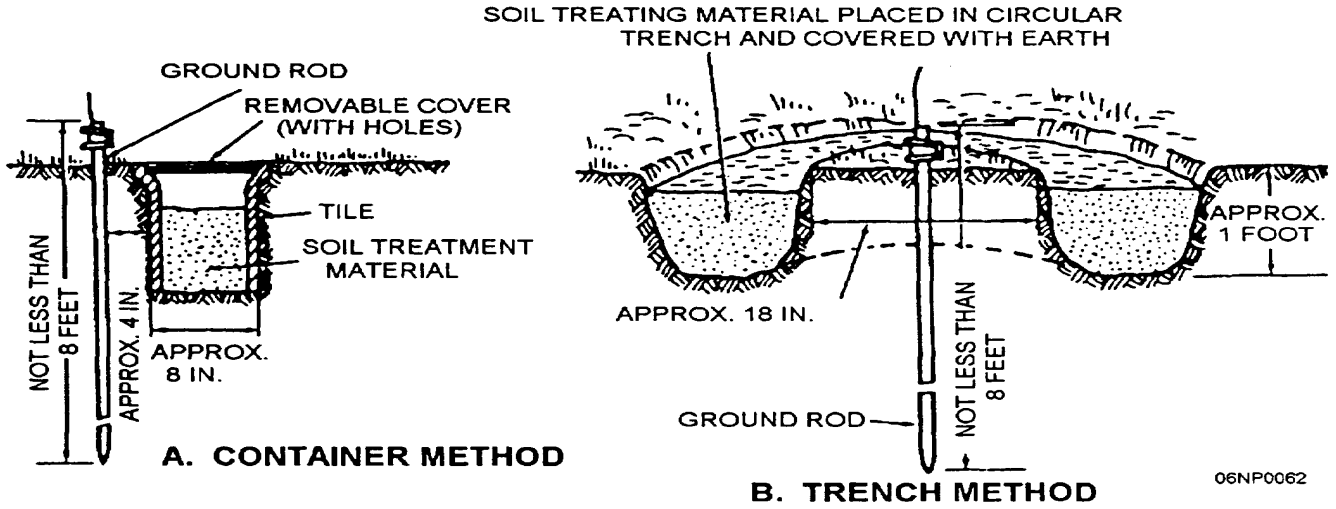

Figure 3-7.—Methods of soil treatment for lowering of ground resistance.

4. A combination of methods may be advantageous and necessary to provide desired ground resistance. A combination of multiple rods and soil treatment is effective and has the advantages of both of these methods; multiple long rods are effective where conditions permit this type of installation.

After you are sure you have a good ground, connect the clamp and the ground cable to the top ground rod section (fig. 3-6, view B), and secure the connection by tightening the screw.

CONNECTIONS

A typical generator set is outlined in figure 3-8, showing the load cables and output load terminals.

WARNING

Before attempting to connect the load cables to the load terminals of a generator set, make sure the set is not operating and there is no input to the load.

Refer to figure 3-8 as you follow this procedural discussion for making load connections.

1. Open the access door and disconnect the transparent cover by loosening six quick-release fasteners. Remove the wrench clipped to the cover.

NOTE: Be sure to maintain the proper phase relationship between the cable and the load terminals; that is, A0 to L1, B0 to L2, and so forth.

2. Attach the load cables in the following order: L0, L3, L2, and L1 as specified in step 3 below.

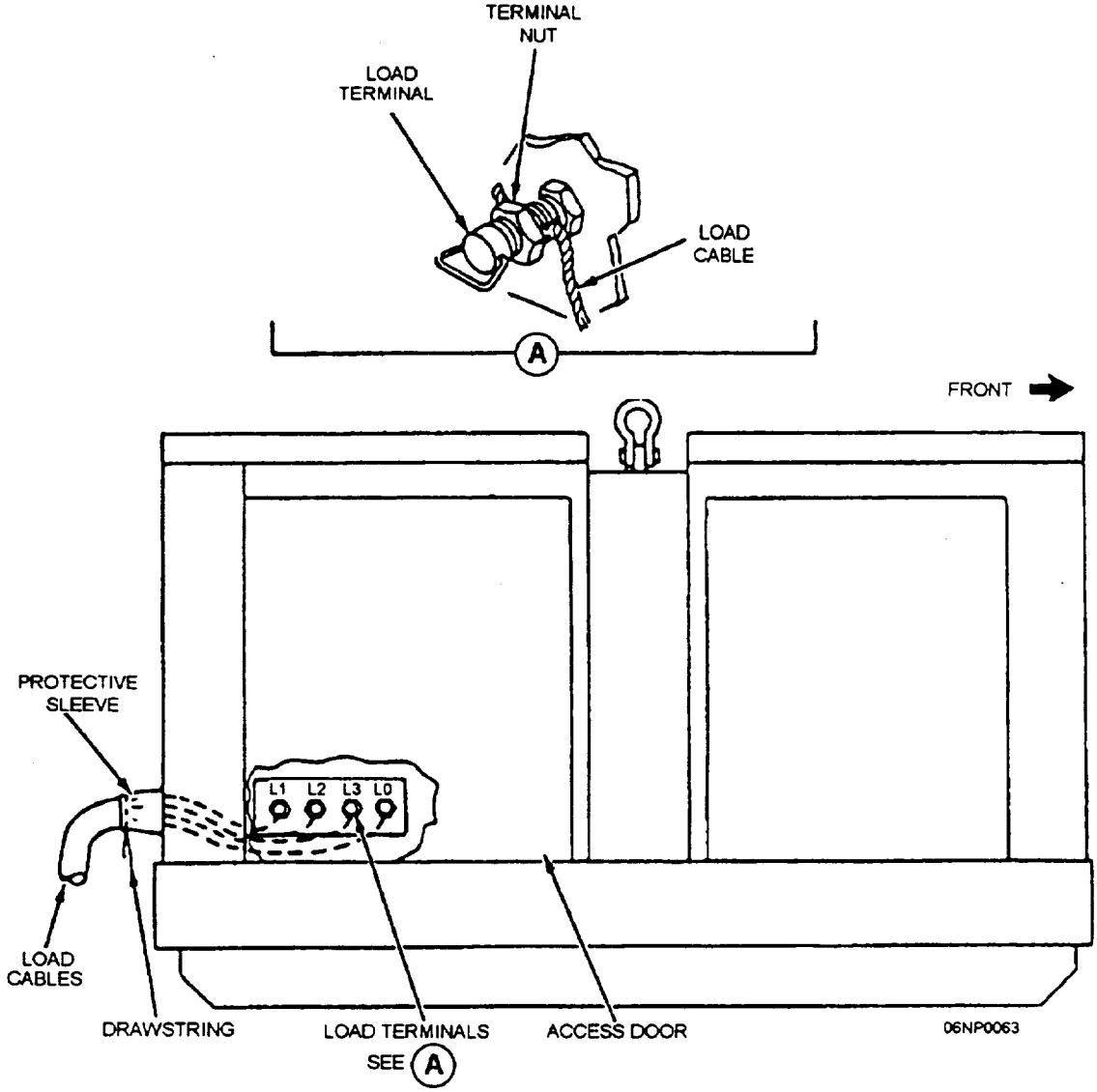

Figure 3-8.—Load cable connections.

3. Insert the load cables through the protective sleeve. Attach the cables to their respective load terminals, one cable to each terminal, by inserting the cable in the terminal slot and tightening the terminal nut with the wrench that was clipped to the transparent cover. Install the wrench on the cover and install the cover.

4. Tighten the drawstring on the protective sleeve to prevent the entry of foreign matter through the hole around the cable.

You may convert the voltage at the load terminals to 120/208 volts or 240/416 volts by properly positioning the voltage change board (fig. 3-9). The board is located directly above the load terminal board.

The procedure for positioning the voltage change board for the required output voltage is as follows:

1. Disconnect the transparent cover by loosening the six quick-release fasteners.

2. Remove the 12 nuts from the board. Move the change board up or down to align the change board arrow with the required voltage arrow. Tighten the 12 nuts to secure the board.

3. Position and secure the transparent cover with the six quick-release fasteners and close the access door.

PHASE SEQUENCE INDICATORS

The phase sequence indicator is a device used to compare the phase sequence of three-phase generators or motors. Examples of its use are as follows: to compare the phase rotation of an incoming alternator that is to be operated in parallel with an alternator already on the line or to determine the phase rotation of motors being put into use for the first time.

One type of phase sequence indicator is a tiny three-phase induction motor. The three leads of the motor are labeled "A," "B," and "C," as shown in figure 3-10. The insulating hoods over the clips are of different colors: red for A, white for B, and blue for C.

The rotor in the instrument can be observed through the three ports as it turns so that you can note the direction in which it rotates. The rotor can be started by means of a momentary contact switch: it, stops again when you release the switch.

You also may use a solid-state phase sequence indicator with two lights. Whichever light is on indicates the phase sequence of the voltage in the conductors that the instrument is connected to; for example, the light labeled "ABC" indicates one phase sequence, while the other light, labeled "BAC," indicates another. If you are working with three-phase conductors (all of the same color) that are installed but not labeled, you may connect the phase sequence indicator to the three conductors, turn on the power, check the phase sequence of the conductors as connected to the instrument, and turn off the power. You may then label the conductors with numbers, letters, or colored marking tape.

You also may check the phase sequence of an incoming alternator before paralleling it with an operating load-side alternator. Connections must be made so that the phase sequence of the two generators will be the same.

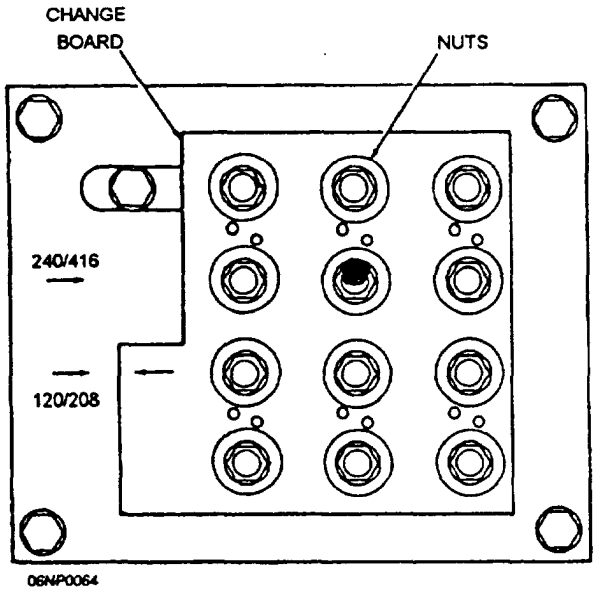

Figure 3-9.—Voltage change board.

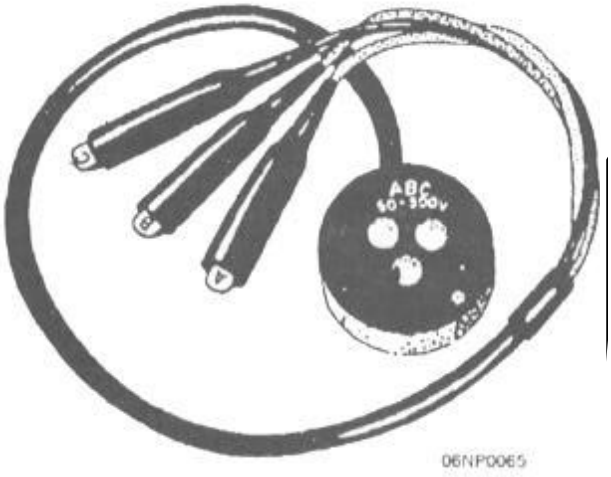

Figure 3-10.—Phase sequence indicator.

Figure 3-11 shows the leads of two generators to be parallel. The proper procedure for ensuring phase sequence with a phase sequence indicator is as follows: Connect indicator terminals A to X_1, B to Y_1, and C to Z_1, press the contact switch, and note the direction of rotation of the rotor.

Now move the A terminal to X, the B to Y, and the C to Z, and again press the switch. If the rotor turns in the same direction as before, the phase rotation is the same for the alternators, and the connection can be made X to X_1, Y to Y_1, and Z to Z_1. If the rotor turns in the opposite direction, transpose the connections of any two of the incoming alternator leads before making the connection.

It is not absolutely necessary that A be connected to the left-hand terminal, B to the center terminal, and C to the right-hand terminal. This is a practical method, however, used to avoid the danger of confusing the leads. The important thing is to ensure that the phase sequence indicator that was used on X_1 be brought down to X, the one used on Y_1 to Y, and the one used on Z_1 to Z. Reversing any two of the leads will reverse the direction of rotation of the rotor of the instrument.

INSPECTION OF THE GENERATOR

Open all access doors of the generator set and make a thorough visual inspection of the generator for loose or missing mounting hardware and damaged or missing parts (look for broken or loose electrical and hose connections, for example, and for loose bolts and cap screws). Also, check the fault indicator panel and control cubicle for broken or missing bulbs and fuses.

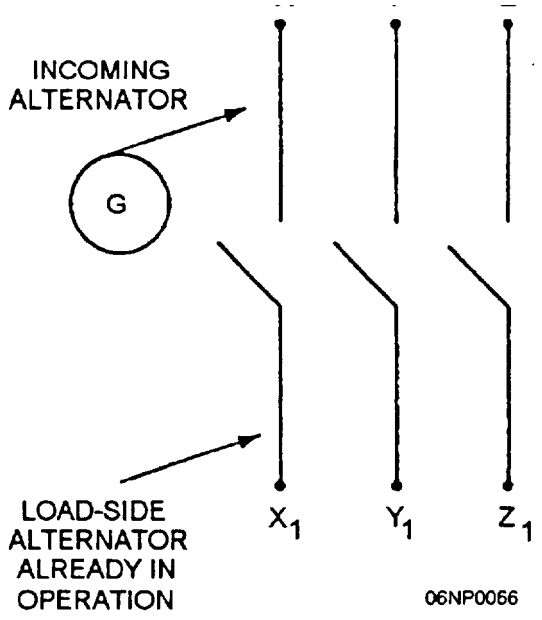

Figure 3-11.—Diagram for checking phase sequence of alternators.

WARNING

While performing your visual inspection, look for service tags. If service tags are present, do not attempt to start or run the generator.

Check the wiring diagrams in the instruction manual furnished with the generator to see whether any wire is connected improperly. If you find faults, correct them immediately.

Be sure to check the levels of the following:

1. Crankcase lubricant.
2. Radiator coolant.
3. Fuel.
4. Electrolyte in the batteries. After donning the proper personnel protective equipment (chemical gloves, goggles, and face shield), add to the actual level to bring it up to the required level, if necessary.

On large generators you should check the area ventilation; the fan cover must be opened and latched in that position. There must be no cover or obstructions over the radiator section. The bypass shutters or doors may be closed to shorten the warming-up period, and roof hatches and side louvers may be opened for additional ventilation, if required.

DISTRIBUTION PANELBOARDS

Power from the generator set must be delivered to various connected loads safely and efficiently. The relatively large cables connected to the load terminal board of the generator, if sized properly, can conduct all the power the generator can produce. This power has to get to the different connected load equipment without overloading the conductors or overheating conductor insulations.

In this section, the makeup of panelboards, connections to them, and the installation of the advanced-base type of portable panelboards are presented.

OVERCURRENT PROTECTION

If the load cables come into contact with each other and short-circuit the generator, the generator windings could be damaged by excessive current unless the generator windings and load cables are protected by a circuit breaker. The circuit breaker "breaks" or interrupts the circuit anytime there is a short circuit or overload condition in the load cables.

One large load, consuming an amount of power at or near the maximum power output of the generator, could theoretically overload the generator in the event of a fault. In this case, one circuit breaker could trip the circuit and protect both the generator and the load. But small-load conductors connected directly to the larger generator load cables could likely burn up without drawing enough current to cause the circuit breaker of the generator set to open the circuit.

In the interest of safe operation of load circuit conductors and safety of area personnel, you must use properly sized overcurrent devices (circuit breakers or fuses).

DISTRIBUTION

The generator load cables are terminated at a type of distribution bus bar from which one or more overcurrent protective devices are connected. Current through each of the overcurrent devices is limited by the overcurrent rating or setting of the device. In this way power from the generator may be safely distributed through protected conductors to the various connected loads.

PANELBOARDS

A panelboard includes buses and automatic overcurrent protective devices placed in a cabinet or cutout box and mounted in (flush) or against (surface) a wall or partition. The panelboard is accessible only from the front. A panelboard serves the purpose mentioned above for the distribution of electric power.

PHASE RELATIONSHIP

When you connect the generator load to the panelboard, be careful to match the cable markings to the panelboard terminals. The same phase relationship should be maintained throughout the wiring system from the generator to the load. You may see terminals marked with numbers, such as L1, L2, L3, and L0 (fig. 3-12, view A) or the letters and symbols A0, B0, C0, and N (fig. 3-12, view B). Wire in different parts of the system may be marked with numbered, lettered, or colored tape. (The color sequence is black, red, blue, and white.) Either way, the phase sequence is the same.

You may have to "ring out" (identify) unmarked cables or conductors in the conduit (fig. 3-12, view C) before connecting them to the power source or load. This identification process can be accomplished in any one of several ways. You may use a bell and battery, buzzer and battery, or ohmmeter, for example. Any of these devices may be used to check for continuity through each conductor to ground (a conduit, for example). After a conductor is identified, it is then marked.

PORTABLE POWER DISTRIBUTION PANELBOARDS

Portable, weatherproof, power distribution panelboards are available, similar to the one shown in

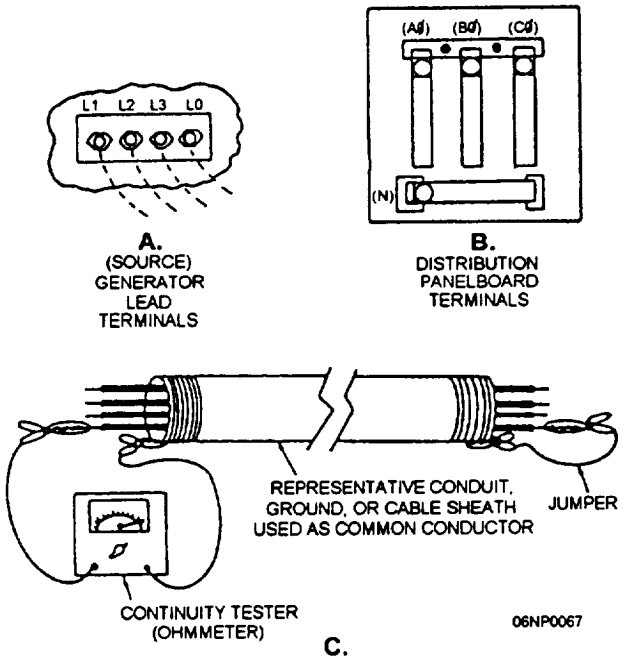

Figure 3-12.—Conductor identification.

figure 3-13. Load cables can be plugged into the receptacles along the front (fig. 3-13, view A). With the cover raised (fig. 3-13, view B), access to the circuit breakers and test jacks is provided. This panelboard is an advanced-base distribution center. A single-line diagram of the bus and circuit breakers is shown in figure 3-14.

Portable generators and panelboards can be placed into service quickly and with relatively little effort, compared to a permanent installation. Do not let expedience cause you to become careless, though, in placing the equipment and routing the load cables. Careful planning can result in a much safer and more efficient installation for both you and your fellow Seabees.

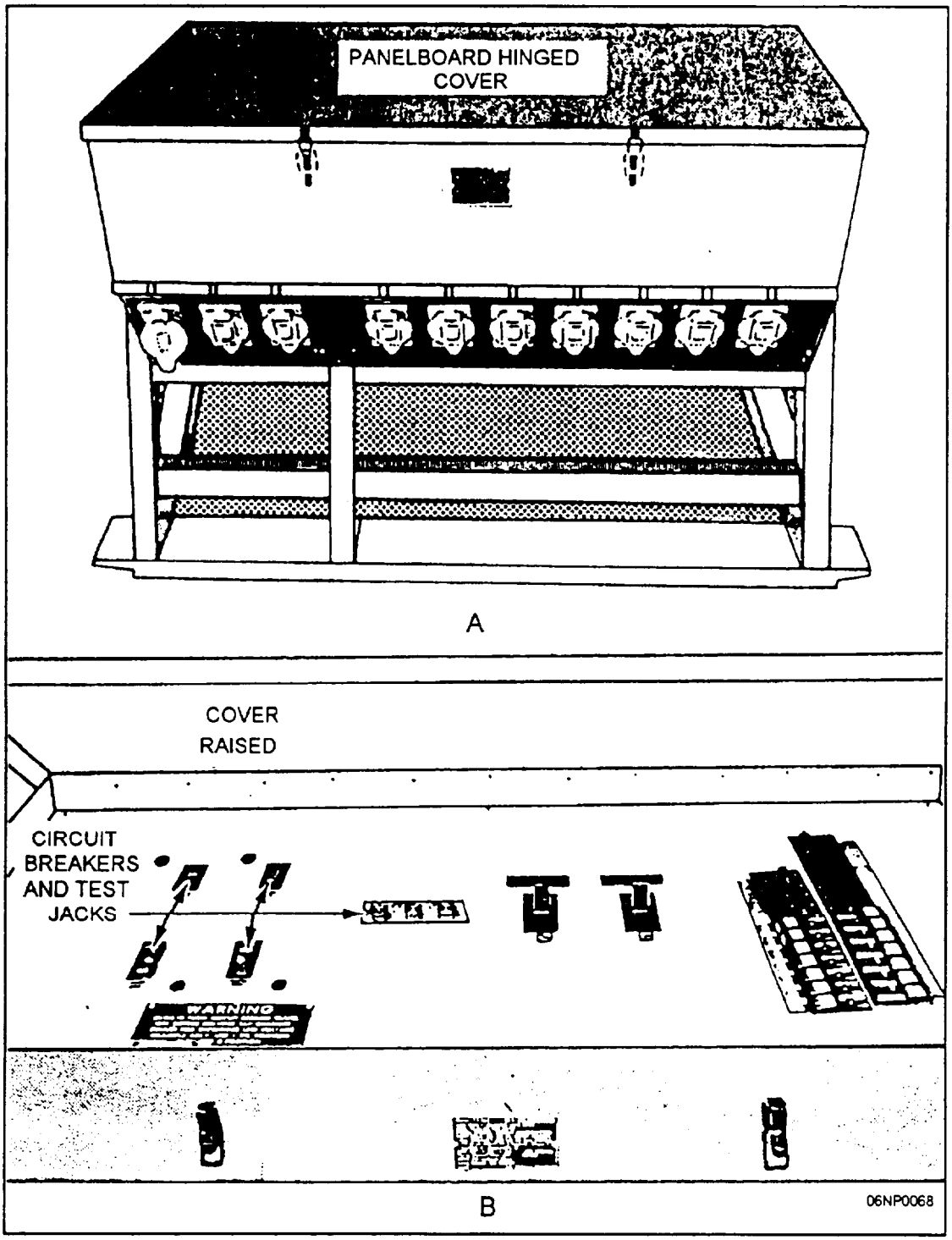

Figure 3-13.—Portable power distribution panelboard.

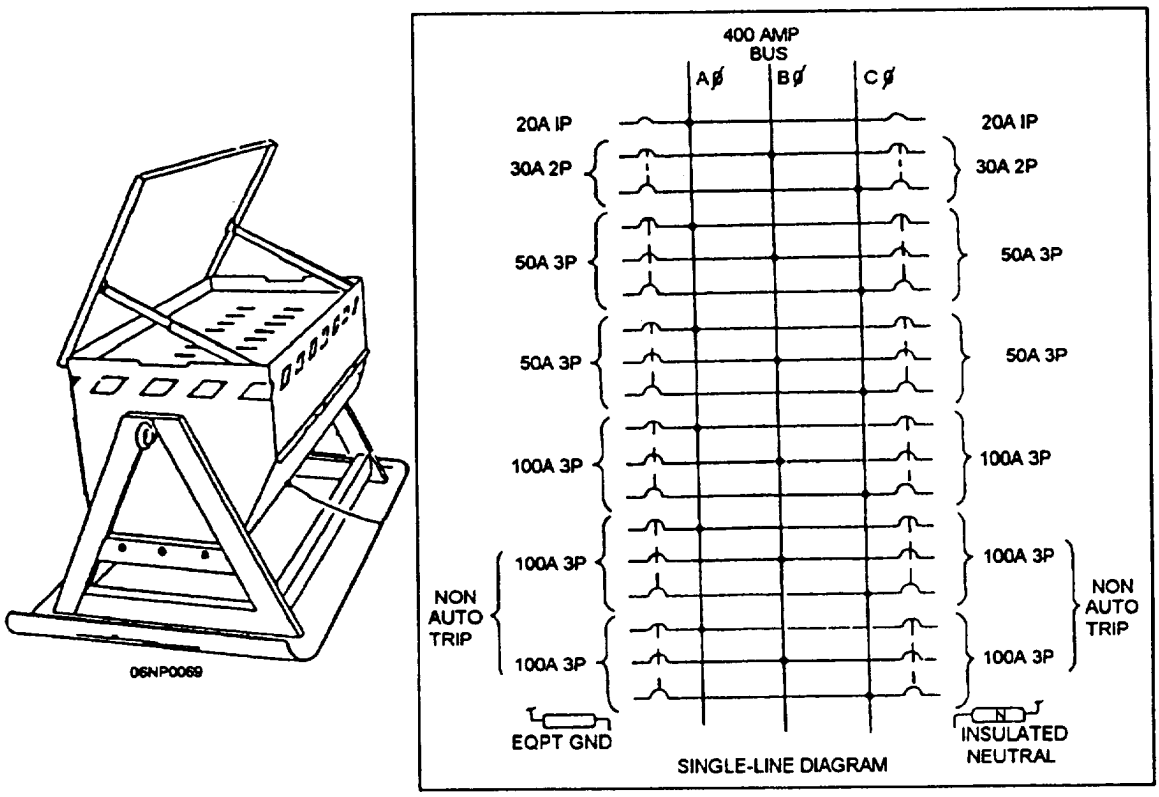

Figure 3-14.—Diagram of the portable power distribution panelboard.

GENERATOR WATCH

While standing a generator watch, you must be alert and respond quickly when you recognize a problem. You might not have control of every situation but at least you can secure the generator and prevent serious problems.

Your primary purpose is to produce power in a safe and responsible manner. You may notice maintenance or repair actions that need to be rectified but do not require immediate attention and do not affect your watch Make note of these problems so that they will be taken care of by the repair crew. In addition, concentrate on doing your job properly, and your efforts will pay off.

A generator watch involves performing operator maintenance, maintaining the operator's log, operating a single generator, or operating paralleled generators.

OPERATOR MAINTENANCE

Operator maintenance generally includes whatever you have to do to start the generator set and keep it running smoothly and safely. Equipment must be inspected systematically so that defects can be discovered before a serious failure occurs. Operator maintenance includes both prestart checks and operating checks.

Prestart Checks

When starting the generator set and preparing to put it on line, you expect everything to go well. A systematic inspection before start-up will help ensure that the generator will operate properly. To do a prestart checkonthe generator, make the following inspections:

1. Ground cable. See that the cable is intact and that the connections are tight.

2. Engine. Compare the actual lube oil level to the appropriate markings (running level or stopped level) on the dipstick. The stopped level is, of course, appropriate for prestart checks. Add oil as required.

Check the engine for loose connections; free action of all moving parts, such as the throttle linkage and the emergency shut-off lever; and for leaking oil, fuel, or coolant.

3. Coolant system. Check that the coolant is at the required level. Add coolant as required. Using an antifreeze solution tester, check that the antifreeze

content is sufficient for the existing ambient temperature. (Refer to the manufacturer's manual for the type and quantity of antifreeze. Add antifreeze as required.) Check the hoses and clamps for security.

4. Batteries. Check the batteries for the required electrolyte level; add distilled water or, if distilled water is not available, clean tap water as required to raise the electrolyte level to the slots in the filler wells.

5. Air intake system. Check the air intake system cleaner for excessive dirt (see AIR CLEANER PANEL FILTER, fig. 3-15); remove and clean the air cleaner panels as required. Check the air intake louvers and radiator grille for freedom of motion, and ensure that they are not clogged.

6. Exhaust extension. Inspect the exhaust extension (where extended through the roof or wall) for condition and tightness at the seams and at the point of coupling near the housing.

7. Alternator (fig. 3-16) and belts. Inspect the alternator for signs of overheating, frayed or loose wiring, and corrosion. Inspect the alternator drive belts and fan belts for proper tension and for cracks, fraying, and other signs of deterioration.

8. Breather. Inspect the breather extension for tightness, general condition, and leakage. Check that the breather coupling is not restricting the flow of air and that the breather exit port is clear.

9. Fuel system. Inspect the electric fuel transfer pumps for secureness, tight fittings, signs of damage, corrosion, leaks, and loose electrical connections.

Look over the fuel filters and strainers for leaks and tight fittings. Drain water and sediment from the

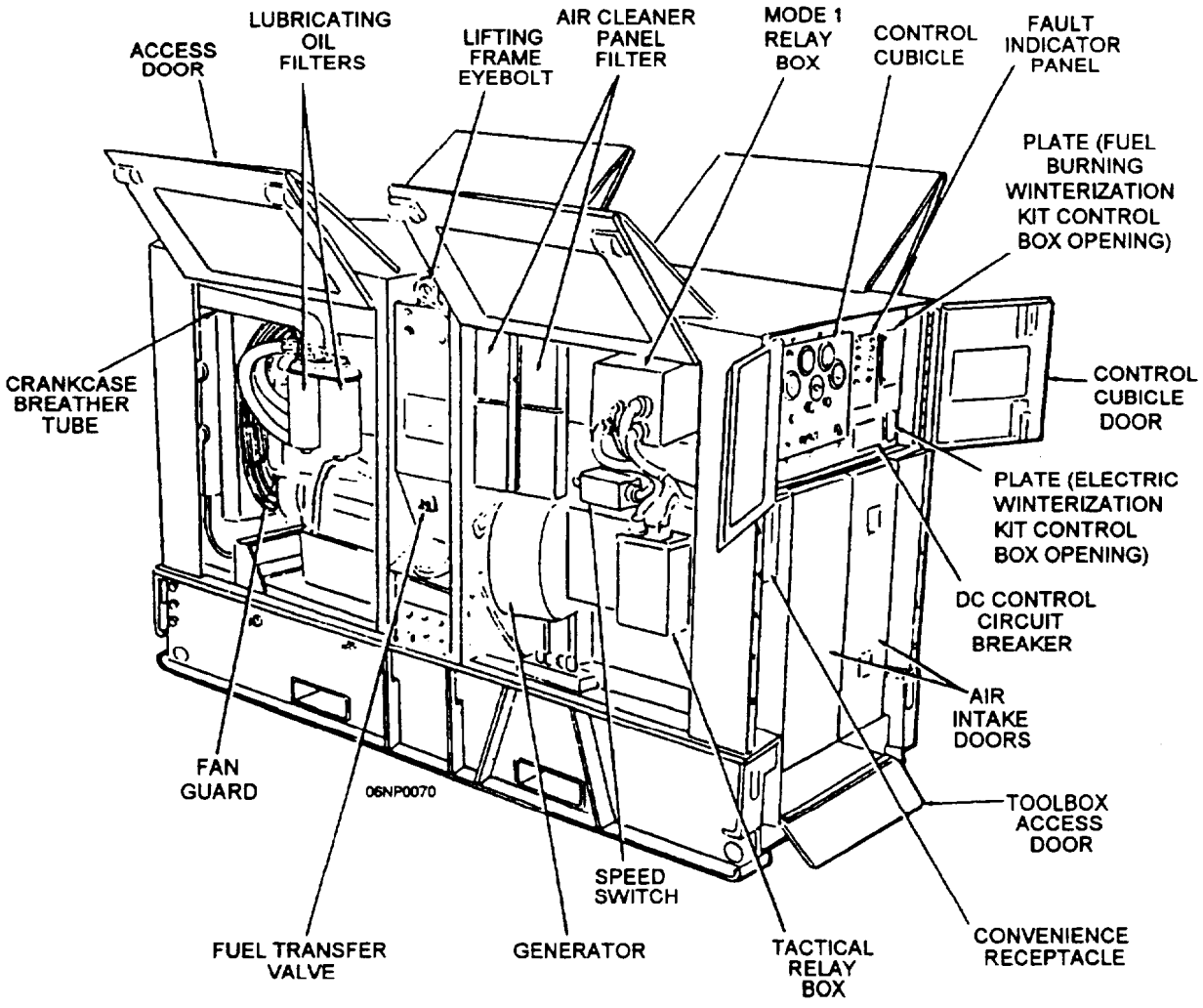

Figure 3-15.—Generator set, left rear, three-quarters view.

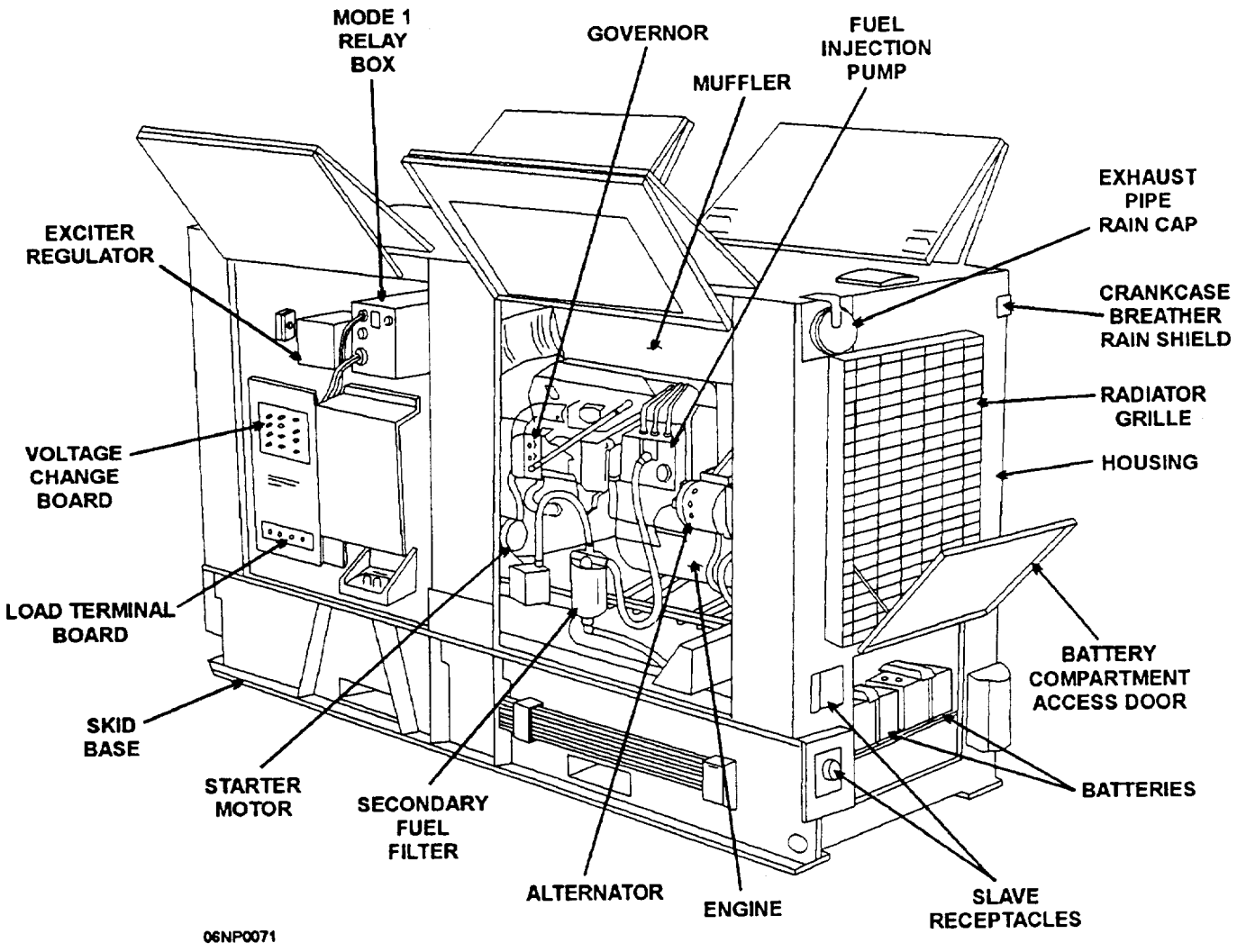

Figure 3-16.—Generator set, right front, three-quarters view.

primary filter and strainer and from the secondary filter, using rags to catch the waste.

Check the day tank for leakage or signs of obvious damage. Remove the cap from the day tank drain valve and open the valve. Drain the water and sediment into a suitable container, close the valve, and replace the cap.

Inspect the fuel lines, valves, and fittings for bent, leaky, or loose connections and signs of obvious damage. Inspect the fuel tank for leakage or obvious damage.

Service the fuel tank as follows:

WARNING

Always maintain constant metal-to-metal contact between the fuel tank filler neck and the spout of the fuel supply. That will prevent the possibility of sparking caused by static electricity.

Remove the fuel tank filler cap and fill the tank with the proper fuel. Replace the filler cap and wipe up any spilled fuel. Remove the cap from the fuel tank drain valve and open the valve. Permit water and sediment to drain into an approved nonflammable container. Close

the drain valve when clear fuel runs out of the tank. Reinstall the cap on the valve.

Remove the fuel filler cap and strainer, as shown in figure 3-17. Check the cap vent valve for proper opening and closing. Inspect the strainer for holes, breaks, and tears. Also, inspect the parts for cracks, breaks, and other damage. Install the cap and strainer, as shown in figure 3-17.

NOTE: The fuel tank filler cap vent valve must be in the open position during operation of the generator set.

10. Ether system. Inspect the ether system (used to aid cold-weather starting). The ether cylinder is strapped to the day tank. Look for broken wires, loose connections, corrosion, and any other signs of obvious damage.

11. Set controls and instrumentation. Inspect meters and gauges at the control cubicle (fig. 3-15) for bent pointers, broken glass, unreadable dial faces, and restricted movement of pointers. Clean gauges and meter faces with a lint-free cloth.

Check for broken indicator lenses and for unreadable lettering. Set the panel light to ON; the panel lights should light.

Check all switches for positive action; each switch should snap from one position to the next.

Operating Checks

The operator can use his or her senses to detect many potential problems. The operator may smell overheated insulation, hear peculiar noises, see an indicating light signaling a fault, or feel unusual vibrations from the generator or engine.

Operator maintenance requirements vary with different types of generators. General operator inspections and tasks are as follows:

1. Oil level. Frequently, check the appropriate oil level. Add oil as needed to maintain the required level. (Intervals between oil checks and changes will vary for abnormal operation and severe conditions.)

2. Batteries. Check the electrolyte level and add water to maintain the required level.

3. Exhaust and breather systems.

WARNING

Components of both the exhaust and crankcase breather systems (muffler, pipe, tube, and hose) become extremely hot during generator set operation. Do not handle any of them while they are hot.

Inspect the muffler for holes, dents, signs of extreme corrosion, and metal deterioration. Also, check

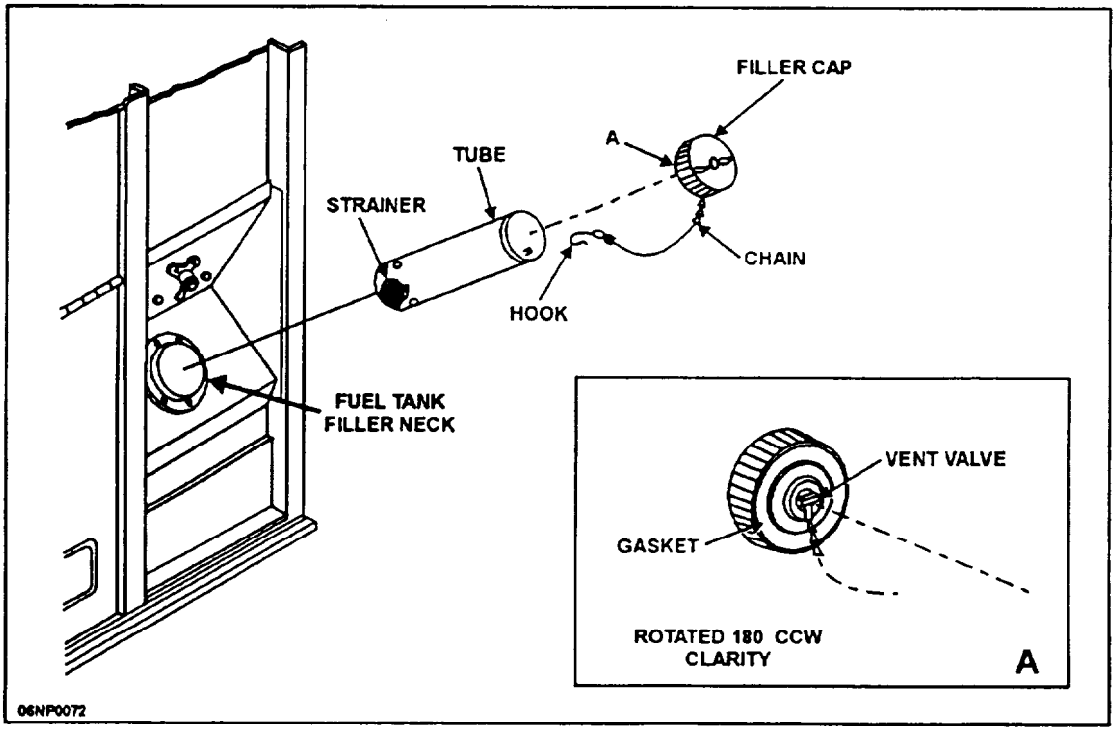

Figure 3-17.—Fuel filler cap and strainer.

for loose or broken clamps and general secureness of the muffler. Check all pipes and ducts associated with the exhaust system for holes, dents, signs of extreme corrosion, and metallic deterioration. Also, check for loose and broken bolts. Check the exhaust ram cap for signs of corrosion and freedom of movement. Check the breather tube and associated hoses for loose clamps, holes in the hoses, and loose bolts.

4. Cooling system. Check all hoses for cracks, cuts, signs of deterioration, and bulges (indicating the possibility of future rupture). Check all clamps for tightness and signs of corrosion.

WARNING

Do not attempt to remove the radiator cap until the radiator has cooled to a point where there will be no built-up steam pressure. Failure to observe this warning could result in second- or third-degree burns.

OPERATOR'S LOG

The operator's log (also called the station log) is a complete daily record of the operating hours and conditions of the generator set. The log must be kept clean and neat. Any corrections or changes to entries for a watch must be made by the person who signs the log for that watch.

The log serves as a basis for determining when a particular piece of electrical equipment is ready for inspection and maintenance. Current and previous logs can be compared to spot gradual changes in equipment condition. These changes might not otherwise be detected in day-to-day operation.

Defects discovered during operation of the unit should be noted for future correction; such correction to be made as soon as operation of the generator set has ceased.

Making accurate periodic recordings is particularly important. The intervals of these recordings will be based on local operating conditions.

The form used for log entries varies with the views of the supervisory personnel in different plants, and there is no standard form to be followed by all stations. Regardless of form, any log must describe the hourly performance not only of the generators but also of the numerous indicating and controlling devices.

Figure 3-18 shows one type of log that may be kept on the generator units of a power plant. This is only a

SUGGESTED FORM OF PLANT OPERATION LOG

Date	Time	UNIT NO. 1785			UNIT NO. 942			UNIT NO. 3465			REMARKS
		☐ speed Time Meter	Volts	Amperes	☐ speed Time Meter	Volts	Amperes	☐ speed Time Meter	Volts	Amperes	
2/8/93	1600	195.0	220	58	302.0	52	220	934.0	220	27	Started up
"	1730	196.5									added 2qts oil to #1785
"	2100	200.0	221	54	307.0	49	221				shut down #3465

OPERATOR _____

Figure 3-18.—Typical generating station operator's log.

suggested form, of course, and there may be many other forms at your generating station to keep records on.

OPERATING PROCEDURES FOR SINGLE GENERATOR SETS

The following operating procedures are general procedures for operating a single generator unit. Some procedures will vary with different types of generators. Study carefully the recommendations in the manufacturer's manual for the generator you are to operate. Learn about the capabilities and limitations of your machine(s). In the event of a problem, you will know what action is required to lessen the effects of the problem. You or your senior should make a checklist of operating procedures from the manual and post it near the generator.

The steps below will cover starting and operating a typical diesel-driven generator set. (This set uses a dc-powered motor for starting the diesel engine.) These steps will also cover applying an electrical load.

Starting the Generator Set

Proceed as follows to start the typical generator set:

WARNING

Do not operate the generator set unless it has been properly grounded. Electrical faults (such as leakage paths) in the generator set, feeder lines, or load equipment can cause injury or death by electrocution.

Before operating the set for the first time, ensure that service procedures were performed upon its receipt according to the manufacturer's literature. See also that all preventive maintenance checks have been performed. The voltage change board must be adjusted for the required voltage (fig. 3-11).

1. Open the CONTROL CUBICLE and AIR INTAKE DOORS (fig. 3-15). Close the HOUSING PANEL (ACCESS) DOORS,

2. Set the FUEL TRANSFER VALVE (fig.3-15) to the desired source of fuel, preferably the auxiliary tank, if it is connected.

NOTE: Refer to figure 3-19 for the CONTROL CUBICLE, FAULT INDICATOR PANEL, DC CONTROL CIRCUIT BREAKER, and ENGINE MANUAL SPEED CONTROL. Notice that the control cubicle is divided into an engine section and a generator section.

3. Set the PARALLEL OPERATION-SINGLE UNIT OPERATION select switch (located in the GENERATOR section of the CONTROL CUBICLE) to SINGLE UNIT OPERATION.

4. Set the VOLTAGE ADJUST-INCREASE control to the lower half of the adjustment range.

5. Depress the DC CONTROL CIRCUIT BREAKER (located to the lower right of the CONTROL CUBICLE) to ON.

6. Set the START-STOP-RUN switch (located in the ENGINE section of the CONTROL CUBICLE) to RUN.

7. Set and hold the TEST or RESET switch (on the FAULT INDICATOR PANEL) in the UP position. Each fault indicator light should be on Check and replace defective lamps or fuses.

8. Allow the TEST or RESET switch to return to the mid-position. Each fault indicator light, with the exception of the LOW OIL PRESSURE light, should go out. When the engine has started, the LOW OIL PRESSURE light should also go out.

NOTE: If the NO FUEL light stays lit, refill the set or auxiliary tank. Position the BATTLE SHORT switch (CONTROL CUBICLE) to ON (the fuel pump will run to fill the day tank). Set the TEST or RESET switch to the UP position and then release it; the NO FUEL light should go out when the switch handle is released.

9. Set the CKT BRK CLOSE-OPEN switch (CONTROL CUBICLE) to OPEN.

10. Push and release the AIR CLEANER CONDITION indicator, BATTLE SHORT indicator, and CKTBRK indicator. Each indicator light should go on as the indicator is pushed and go out when the indicator is released.

a. If the AIR CLEANER CONDITION indicator remains lit, the air cleaner must be serviced.

b. If the CKT BRK indicator remains on after you set the CKT BRK switch to OPEN, you cannot continue the procedure. The circuit breaker must function properly. The generator cannot be used until the problem is corrected.

11. Depress the lock button on the ENGINE MANUAL SPEED CONTROL (located below the DC CONTROL CIRCUIT BREAKER), and set the control.

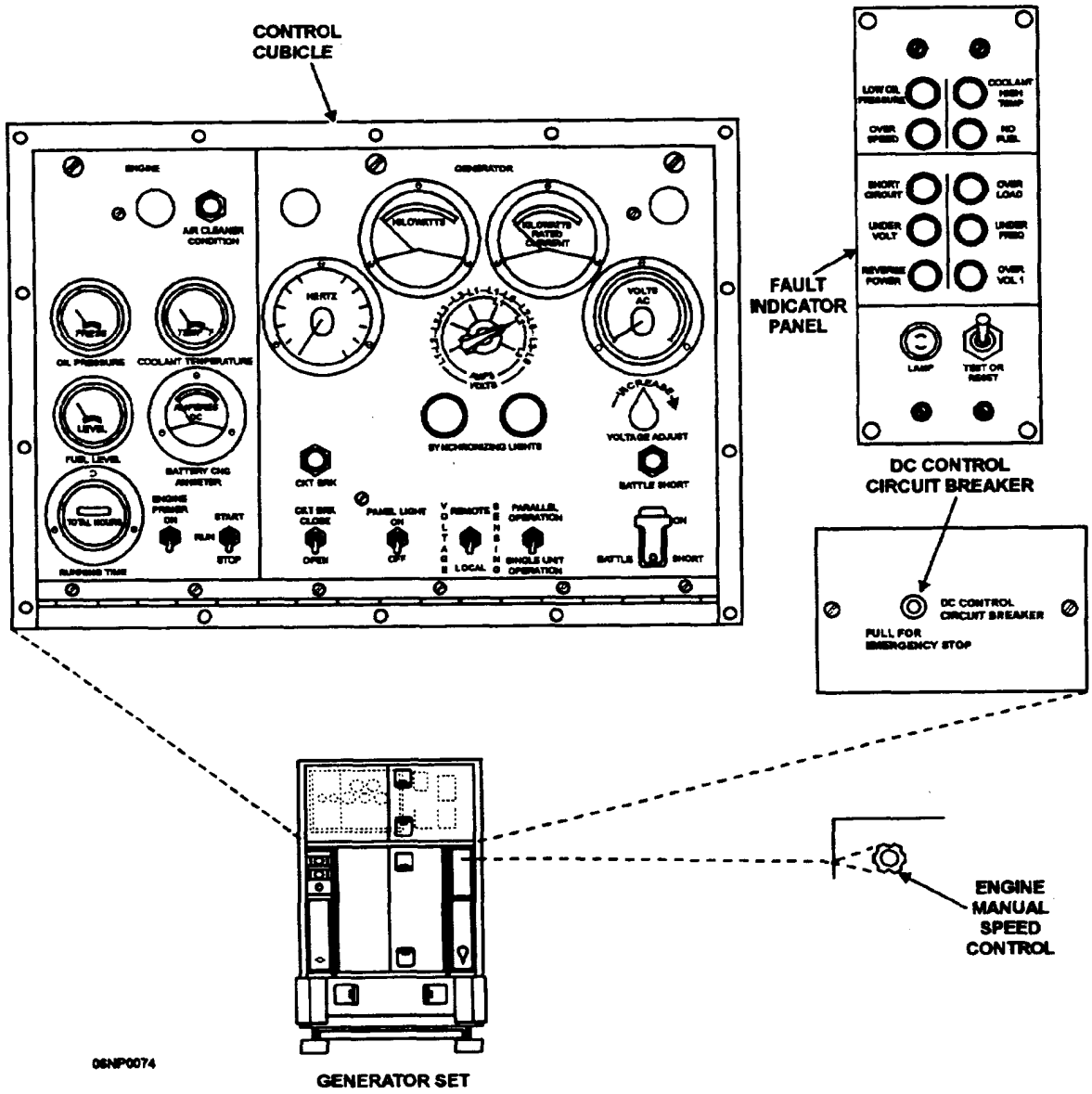

Figure 3-19.—Control cubicle, controls, and indicators.

CAUTION

Do not crank the engine in excess of 15 seconds at a time. Allow the starter to cool a minimum of 3 minutes between cranking.

WARNING

Operation of this equipment presents a noise hazard to personnel in the area. The noise level exceeds the allowable limits for unprotected personnel. Wear earmuffs or earplugs.

12. Set and hold the START-STOP-RUN switch to the START position until the engine starts. As the engine starts, observe the following:

a. The OIL PRESSURE gauge indicates at least 25 psig.

b. The VOLTS AC meter indicates the presence of voltage.

c. The LOW OIL PRESSURE indicator light on the FAULT INDICATOR PANEL goes out.

13. Release the START-STOP-RUN switch. Position the switch to RUN.

Operating the Generator Set

The procedures for operating a single generator set (single unit) are as follows:

1. Ensure that the PARALLEL OPERATION-SINGLE UNIT OPERATION switch (fig. 3-19) is set to SINGLE UNIT OPERATION.

2. Position the AMPS-VOLTS selector switch to the required position. Rotate the VOLTAGE ADJUST control to obtain the required voltage. Read the voltage from the VOLTS AC meter.

3. Depress the locking button, and slide the ENGINE MANUAL SPEED CONTROL in or out to obtain the approximate rated frequency; rotate the vernier knob (the knob on the control) clockwise or counterclockwise to obtain the rated frequency.

NOTE: If necessary, the load may be applied immediately.

4. Operate the engine for at least 5 minutes to warm it up.

5. Apply the load by holding the CKT BRK switch (on the CONTROL CUBICLE) to CLOSE until the CKT BRK indicator lights go out. Then release the switch.

6. Observe the readings from the VOLTS AC meter and the HERTZ (FREQUENCY) meter. The voltage readings should be 120/208 to 240/416 volts ac (depending on the positions of the AMPS-VOLTS select switch and the voltage change board). Let's say, for example, that you positioned the voltage change board for 120/208 volts before you started the generator set. When you position the AMPS-VOLTS selector switch to L2-L0 VOLTS/L2 AMPS while the generator is operating, the VOLTS AC meter should indicate 120 volts. The PERCENT RATED CURRENT meter will indicate the percent rated current (not more than 100 percent) between generator line 2 and neutral. The HERTZ (FREQUENCY) meter should indicate 50 or 60 hertz. The KILOWATTS meter should indicate no more than 100 percent with the HERTZ (FREQUENCY) meter showing 60 hertz. Readjust the voltage and frequency, if necessary.

7. Observe the KILOWATTS meter. If the meter indicates that more than the rated kilowatts are being consumed, reduce the load.

8. Rotate the AMPS-VOLTS selector switch to each phase position and monitor the PERCENT RATED CURRENT meter. If more than the rated load is indicated for any phase position, reduce or reapportion the load.

9. Periodically (not less than once per hour), monitor the engine and generator indicators to ensure their continued operation.

10. Perform any "during operation" preventive checks according to your checklist.

When in operation, the generator set should be monitored periodically (at least once an hour) for signs indicating possible future malfunctions.

After the warmup, the lubricating oil pressure should remain virtually constant. Check and record the level of lubricating oil while the engine is running normally. If any significant changes occur in the oil pressure, notify the maintenance personnel. Check and record the coolant temperature of the normally running engine. Notify maintenance personnel if the coolant temperature changes significantly.

Learn the sounds of a normally running generator set so that any unusual sounds indicating the possible start of a malfunction may be detected early enough to avoid major damage.

Stop the operation immediately if a deficiency that wouldd damage the equipment is noted during operation.

OPERATING PROCEDURES FOR PARALLELING GENERATORS

This section will include procedures for paralleling generators, removing a set from parallel operations, and stopping generator set operation.

NOTE: These procedures assume that one generator set is on line (operating and connected to the distribution feeder lines through the switchgear). The set that is to be paralleled is designated the incoming set (fig. 3-20).

CAUTION

When you are operating generator sets in parallel, they must have the same output voltage, frequency, phase relation, and phase sequence before they can be connected to a common distribution bus. Severe damage may occur to the generator sets if these requirements are not met.

Adjusting the engine speed of the incoming set while observing the output frequency and the

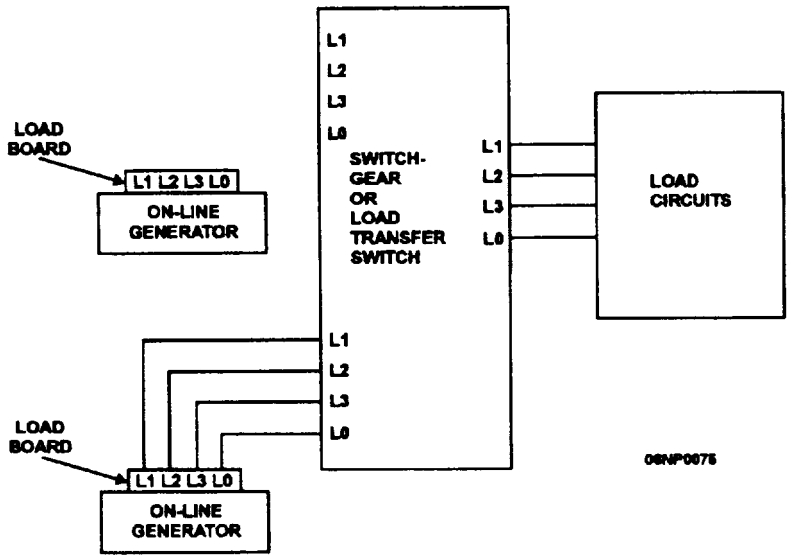

Figure 3-20.—Parallel operation connection diagram.

SYNCHRONIZING LIGHTS (fig. 3-19) will bring the phase and frequency into exact agreement. As the phase and frequency approach the same value, the SYNCHRONIZING LIGHTS will gradually turn on and off. When the blinking slows to a rate of once per second or slower, close the main circuit breaker of the incoming set while the SYNCHRONIZING LIGHTS are at a point of being dark. The phase sequence relates to the order in which the generator windings are connected. If the phase sequence is not correct, the SYNCHRONIZING LIGHTS will not blink on and off together. When the incoming set is first connected to the load through the appropriate switchgear (fig. 3-20). you should observe one of four occurrences. When the phase sequence, voltage, frequency, phase, and engine performance are the same, the changeover will be smooth with only the slightest hesitation in engine speed; if each output is slightly out of phase, one of the engines will shudder at the point of changeover; if the phase sequence or voltage levels are incorrect, the reverse power relay will trip on one of the generator sets and open its main circuit breaker contactors; if the incoming generator set loses speed significantly or almost stalls, the incoming engine may be defective.

CAUTION

Should either generator set lose speed, buck, or shudder when the incoming set is connected to the distribution feeder lines, immediately flip the CKT BRK switch of the incoming set to open, and then recheck the paralleling set-up procedures.

Refer to figures 3-19 and 3-20 to set up the generator sets for parallel operation.

WARNING

When performing step 1, make certain that the incoming set is shut down and that there are no voltages at the switchgear terminals being connected to the incoming set. Do not take anybody's word for it! Check it out for yourself! Dangerous and possibly deadly voltages could be present. Take extreme care not to cross the LO (neutral) with any of the other phases (L1, L2, or L3).

Paralleling Procedures

1. Connect the incoming set, as shown in figure 3-20.

2. Make certain that the voltage change board (reconnection board) (fig. 3-12) of the incoming generator is set up for the same output voltage as the on-line generator.

3. Set CKT BRK switch on the incoming set to OPEN. When the incoming set circuit breaker is open (CKT BRK indicator light will be out), operate the load switchgear so that the on-line output voltage is present at the voltage change board of the incoming set.

4. Set the PARALLEL OPERATION-SINGLE UNIT operation switch on both sets to PARALLEL OPERATION.

5. Start the incoming set. The on-line set should be in operation already.

6. After a 5-minute warmup, try the VOLTAGE ADJUST control on the incoming set until the output voltages of both sets are equal.

CAUTION

If the synchronizing lights do not blink on and off in unison, the phase sequence is incorrect. Shut down the incoming set and recheck the cabling to and from the incoming set.

7. On the incoming set, position the ENGINE MANUAL SPEED CONTROL until the SYNCHRONIZING LIGHTS blink on and off as slowly as possible.

8. With one hand on the CKT BRK switch, adjust the ENGINE MANUAL SPEED CONTROL vernier knob until the SYNCHRONIZING LIGHTS dim gradually from full on to full off as slowly as possible. Just as the SYNCHRONIZING LIGHTS dim to out, set and hold the CKT BRK switch to close. When the CKT BRK indicator light comes on, release the switch.

9. On both sets, check that the readings of the PERCENT RATED CURRENT meters and KILOWATTS meters are well within 20 percent of each other. If not, increase the engine power of the set with the lower readings (by adjusting the ENGINE MANUAL SPEED CONTROL to increase the speed) until the readings are about equal.

NOTE: The division of the kilowatt load is also dependent on the frequency droop of the two sets and must be adjusted at the next higher level of maintenance. If the current does not divide as described above, adjust the reactive current-sharing control located at the right side of the special relay box for equal reading on both percent rated current meters.

10. On the incoming set, readjust the voltage and frequency of the output until it is equal to the output of the on-line set.

Removing a Generator Set from Parallel Operation

Refer to figure 3-19 while following the procedure for removing a generator set from parallel operation.

CAUTION

Before removing the generator set(s) from parallel operation, make sure the load does not exceed the full-load rating of the generator set(s) remaining on the line.

1. On the outgoing set, position and hold the CKT BRK switch to OPEN until the CKT BRK indicator light goes out. Release the switch.

2. On the outgoing set, allow the engine to operate with no load for about 5 minutes.

3. On the outgoing set, pull the DC CONTROL CIRCUIT BREAKER to OFF.

4. On the outgoing set, set the START-STOP-RUN switch to STOP.

WARNING

Make certain the outgoing set is shut down and there are no voltages at the switchgear terminals connected to the outgoing set. Do not take anybody's word for it! Check it out for yourself!

5. Disconnect the cables going from the outgoing set to the load switchgear.

Stopping Generator Set Operation

Refer to figure 3-19 as you study this section.

1. Set the CKT BRK switch to OPEN until the CKT BRK indicator light goes out, then release the CKT BRK switch.

2. Allow the engine to cool down by operating at no load for 5 minutes.

3. Set the START-STOP-RUN switch to STOP.

4. Close all generator doors.

MAINTENANCE

There are actually three major categories (or levels) of maintenance. The three categories are (1) depot, (2) intermediate, and (3) organizational. In depot or intermediate maintenance, equipment is restored to like-new condition or subjected to some degree to detailed repairs. Under the organizational category, generator maintenance may consist of inspection, testing, adjustment, and so forth, and then perhaps

replacement of, rather than repair of, a faulty component.

Two types of organizational maintenance are (1) operator and (2) preventive. Each of the two types should complement the other.

Defects discovered during operation of the unit will be noted for future correction either by the operator or by maintenance personnel, as appropriate. The purpose of preventive maintenance is to keep the machinery running trouble-free. The operator will likely have fewer problems if the preventive maintenance work is done well.

In our previous discussion we have seen that operator maintenance includes many of the tasks you do before, during, and after you operate the generator set to produce power.

As a member of a unit or organization large enough to have a maintenance crew, you may serve as a member of the crew. As a crew member, you will perform organizational preventive maintenance functions on the generator set periodically according to the manufacture's specifications or to service maintenance manuals.

To prevent buildup of contaminants that may cause damage to the operating components or systems of the generator set, you should clean the set periodically. Cleaning operations must be performed only on generator sets that are not operating, that are connected to a parallel bus, or that are connected in a standby mode. To clean the generator set, heed the warnings and cautions given, and proceed as follows:

WARNING

Compressed air used for cleaning can create airborne particles that may enter the eyes. Pressure shall not exceed 30 psig (206 kPa). Wearing of goggles is required.

CAUTION

Exercise care to prevent dry-cleaning solvent from coming into contact with electrical components.

Painted metal surfaces should be wiped with a clean lint-free cloth moistened with cleaning solvent (P-D-680, type II). Hard deposits may be scrubbed off with a bristle brush that has been dipped in solvent. Dry the surfaces with a clean lint-free cloth.

WARNING

Dry-cleaning solvent, P-D-680, type II, is flammable and moderately toxic to the skin and eyes. Respiratory and eye protection are required.

Remove any dust, dirt, or sand from inside the generator set with a damp, lint-free cloth.

Disconnect the battery cables (negative cable first) and remove any corrosion from the battery terminals, cables, and hold-down with a wire brush. Clean the battery filler cap vent holes.

Clean the instrument faces with a clean, lint-free cloth.